A Paradigm Shift in Higher Education in the Context of the Fourth Industrial Revolution

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***Abstract*— The Future of Work is upon us and has rapidly and profoundly influenced many professions and industries. Alongside this, we argue that it is essential for the landscape of post-school education and training (PSET) both in South Africa and globally to adapt to the changing nature of work, and ideally lead this change. In this paper we will summarize learning the nexus between teaching, research and innovation as a service in the context of the fourth industrial revolution (4IR), given the innovative technologies that are increasingly penetrating the mainstream. We discuss the transition towards an augmented approach, University 4.0, and the associated challenges, both technological and societal that accompanies the shift.**

***Index Terms*—Artificial intelligence, educational technology, intelligent systems, COVID-19.**

I. Introduction

ON the eve of the ongoing Cricket Test Series between South Africa and England, intertwined with our regular discussion on which team would emerge victorious, we also debated whether computational algorithms could predict the outcome of this match. It was something we also debated during the Rugby World Cup Final between the two nations. Perhaps we could predict - if we had access to higher quality data of the players, weather conditions, the crowd, cheerleading, computational resources, and so on. Some argue that self-learning algorithms can use abundant data and correlation techniques as a possible alternative to high-quality data. Anyway, abundant data, of various scenarios, is perhaps also a tall order.

Vast amounts of variability necessitate tremendous computing power. How exactly does one address "infinite" computing or processing of data in the fourth industrial revolution (4IR)? We really do not have an answer to the infinity question, yet, but an asymptomatic response lies in cloud computing. Simply put, cloud computing is a distributed form of computing where computing power connects remotely, thus extends, and over the internet. Similar to the way that computing power distributes in a virtual way, it is imminent that human power, or the future of work, will also change. It is therefore also essential for the post-secondary education and training (PSET) landscape in South Africa and elsewhere to analogously change. Ideally, PSET has to lead this change.

Looking back at previous industrial revolutions (starting from the very beginning in the mid-18th century), limitations of existing higher education systems were discovered quite abruptly. The necessity for development of new disciplines were abundantly clear, and we have been experiencing a similar situation with the advent of 4IR. Considering the higher education system as an industry in and of itself is by no means unheard-of, seeing that it generates nearly $400 billion of economic activity in the U.S. alone [1].

Perhaps a suitable metaphor for the methods by which universities navigate and respond to the trends of the time such as digital disruption and rapidly morphing labor markets is indeed to denote them as being part of the University 4.0 evolution. Characteristics of the new University 4.0 paradigm have slowly been introducing themselves to an extent, with a unique acceleration occurring during the year that the globe has been struck by the COVID-19 pandemic. Aspects of higher education such as on-demand learning, an increased focus on shorter term qualifications (short term learning programs, for example), prevalence of career management at an undergraduate level and coordination with industry (fulfilling the role of broker between entrepreneurs and potential supporters), have muscled their way to the forefront of our re-imagining of university education.

In 4IR, the pace of change has been more than in the past. This contends traditional PSET (slow to change) and at the same time, new players and business models are rapidly emerging. PSET providers, particularly staff, have to learn the many changes and be exemplars themselves. This does require both a top-down and bottom-up approach – the change management should be strategically enabled. The change is, however, not only to bring about education "efficiencies," but a way of thought in which disruptions become a new norm.

II. Emerging Technologies Leading Towards University 4.0

The profound escalation in performance and availability of connected mobile devices alongside continually down-trending prices for high-speed internet access, coupled with quality online educational tools (online courses, interactive and remote learning, etc.) has brought about drastic paradigm changes to the delivery of educational services. Alongside this, the COVID-19 pandemic has perhaps forced many

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institutions to ramp up their adoption of this new type of educational service delivery, given the necessity for online distance learning. With COVID-19, in a way, the online approach was forced upon. Geographical borders became more virtual than before and new education business models have emerged. This brings about a prominent change in engagement of international students – the landscape has changed. Institutions with significant brand leverage, often well resourced, are elevating competition. At the same time, technology companies with the ability to disrupt are also coming to the fore.

The aspect of learning, which can be seen as the nexus between teaching, research, innovation and community service. Learning is evolving in the form of "University 4.0" – University as a "platform," thus, in cloud computing terminology, one could think of "University 4.0" *as a service*. When thinking of "X" [software or software platform] as a service over the internet, one must keep in mind the dangerous corollary that inevitably follows – the services of the dark or deep web. Hidden in the layers, of this dimension of the web, is the aspect, for example, of ransomware *as a service* [2]. Analogous to the online "rise," cybersecurity challenges have simultaneously grown during the COVID-19 period. The approach to deal with cybersecurity will require an augmented approach – data collected, deep learning algorithms, coupled with human intervention [3]. In other words, like the approach for managing spam, deep learning technologies will be a key contributor in dealing with cybersecurity and associated challenges.

Emerging technologies have always been around and thus the third industrial revolution. For 4IR, our thinking is shaped primarily by artificial intelligence (AI) and the aspect of deep learning. What is amazing here is that the world, like the ocean, has data. We often use the ocean analogy – there's an expression that in the ocean, there's so much water, yet not a single drop to drink. Likewise, the digital economy contains astronomical amounts of data, but we contend with many limitations that prevent us from utilizing all of this data in any meaningful kind of way. Through the third industrial revolution, we now access (say) 25 % of the data that we have, this could be because the available technologies for computing and communication have not yet converged in a manner that is sufficiently sophisticated. We have the opportunity to harness, through 4IR technologies (machine learning and increasingly, deep learning), the other aspects of available and emerging data. We have to do this carefully and through "appropriate" technologies and an ethical approach. For example, we were enthused by smart metering data provided the other day. A side-by-side comparison of the metering data with the traffic data however revealed that we're getting information about what people are doing, where they are at what time, and so on. Such traffic systems also face probable security breaches, compromising data privacy and trust. There's thus an unintended "collusion" of computing algorithms and potential for "algorithm colonization" and we therefore have to ensure that our take is in a multi-dimensional way. This approach will help us evaluate and utilize technology for the ecosystem of learning. This problem is in part being addressed by a strong push for open access software with less restrictive licensing, which effectively decentralizes a large portion of the digital marketplace.

Blockchain technology burst into the public eye with the rapid increase in US dollar-value experienced by Bitcoin, the most widely-known cryptocurrency, nearing the end of 2017. Setting aside the cryptocurrency space, the underlying blockchain technology could prove invaluable for data security and integrity and solves many of the problems experienced with centralized networks. The history of a digital asset stored in a blockchain is both transparent and unalterable through its decentralized nature and strong encryption. Trusting a central authority is removed from the equation, seeing that it is rather established through network consensus, essentially a marriage of public information with a system of counterbalances that maintains block integrity and creates trust between users. Blockchain technology could, however, also play a role in the way course credits compile towards a qualification. Accompanying certification could also be verifiable. One example is the utilization of blockchain technology for education credit and grading systems, available on the EduCTX platform [4]. Within the broader physical infrastructure, Blockchain technology has wide-ranging applications including the asset value-chain, library access and copyright as well as student records and profiles [5].

III. Applications of 4IR in Higher Education

Perhaps the most widely recognized application of the digital revolution to education are massively open online courses (MOOCs). Removed from the classical model of students gathering in a lecture hall, the MOOC paradigm eliminates the requirement for physical proximity in order to deliver lectures. Moreover, classes that are much larger than a typical university classroom can be accommodated and expanded with little to no infrastructure-related obstacles. The demand of such services is self-evident, with the exponential increase in the availability and utilization of services such as Coursera, edX, Udemy, Skillshare, to name but a handful. However, one should be careful with evaluating MOOCs on the same terms as conventional university classroom-based instruction, as these two pathways serve different roles. Coupled with distance learning programs (albeit not unique to such programs) are active discussion boards, where students can interact with each other and the instructors and tutors. An evolution of classroom instruction could just as easily be virtual and live-action, as opposed to pre-recorded and available on-demand. MOOCs in this sense are much more useful to augment the fundamental education experience, credit transfer in some instances, rather than to replace it entirely. In programs where a laboratory component is required, innovative alternatives may be possible. For example, a project-based learning experience could enable "learning by doing" and simultaneously multidisciplinary approach to education. A conceptual diagram illustrating these

concepts is shown in Figure 1, highlighting the interactive nature of remote learning applied to the traditional classroom.

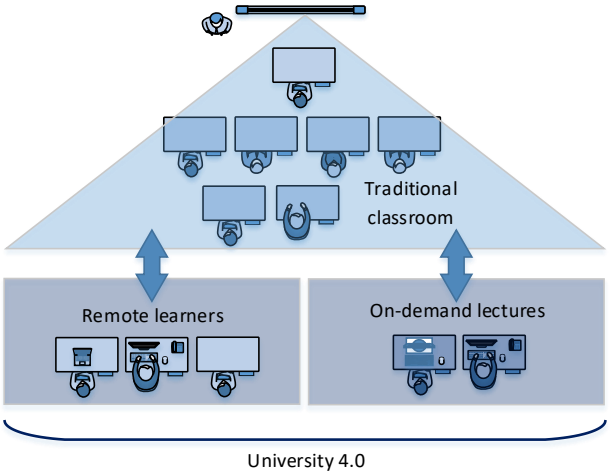

Figure 1. Illustration of expanding the University into the online space.

Another application which rapidly gained traction is the automation of administrative tasks. Gradescope, a tool that automates the grading process of almost any subject area, is utilized by more than a thousand universities [6]. The aim of this service is to provide strong assistance with handwritten or online assignment grading, and enables detailed reporting on the progress of each student in addition to identifying potential problem areas for early warning. This allows instructors and tutors to spend their time more valuably elsewhere - feedback captured from users over a four-year period revealed that two-thirds of users reported time savings of more than 30% - and other administrative tasks could be tackled through similar means. Larger numbers of students could be reached in this way with roughly the same amount of teaching and administrative resources, and users are generally able to grade with greater consistency and flexibility, seeing that the platform allows back-annotation of rubric modification. Moreover, Gradescope provides students with greater transparency in grading methodology which efficiently aids in learning from mistakes.

Using AI to improve writing (technical and otherwise) can be accomplished through Grammarly [7]. Grammarly is a tool that intelligently plugs into a web browser, document generation software and even mobile and desktop operating systems. It utilizes a natural language processing (NLP) engine to improve writing style, enhance clarity and conciseness, expand vocabulary, and even provides an estimate of the tone conveyed by a particular message. Grammarly can therefore be useful to improve writing and communication in a variety of settings, in addition to academic writing for students and academic staff alike. In an integrated approach, where the student completes a first evaluation, the workload for the instructor is reduced. The approach of Grammarly to evaluate text, for emotions, and improve the writing "behavior" illustrates the 4IR future trajectory.

IV. On the other hand, one could argue that the AI-based tools are paid twice – they earn from software licensing and simultaneously as the data enrich their own capability! University Education as a Service

The modalities for credentialing continue to evolve. The University of Johannesburg (UJ) has recently implemented digital certificates, badges, the aspect of open online courses and collaboration. The university has implemented a continuing education program, using a cloud computing platform, through the Applied Information Systems Department (part of the College of Business and Economics). Here we are exploring the approach of cloud computing, as a service, and how scalable high-performance computing could be used by businesses and universities. The cloud computing platform being used, as an example, is Amazon Web Services (AWS). The approach also couples with AWS certification and for additional graduate value-add. The aspect of learning "as a service" was mentioned earlier and we will continue by placing greater emphasis on research and innovation.

Some further AI-based examples of how learning and innovation couple: we've implemented a tool, Teqmine, which harvests intellectual property (IP) with commercialization potential, as an input into the learning process, this helps to identify IP "collaborators" – internal and outside of the university. Various initiatives to increase participation in *netpreneurship* (that is, online businesses without any physical offices) among the youth population are in the works (the Africa Netpreneur Prize is one of these). Youth have a greater uptake for technology and we except a rise of netpreneurship through similar avenues. We therefore foresee a blend of innovation to all aspects of teaching and learning, the university "as a service" would enable bringing together of IP, internal to the institution and also otherwise – we live in exciting times.

Paradigm shifts are hard to implement – the PSET sector can be slow to adopt and we've to find ways of disrupting the system. At UJ, we've implemented a 4IR catalytic set of initiatives, over 5-years, and piloting initiatives. Firstly, we're aggressively recruiting from academia and industry, postdoctoral research fellows, master's and doctorate students, professors of practice, and so on. Secondly, we're catalyzing 4IR evangelists in both the academic and professional domain. Our library, often seen as the heart of academia, has implemented a number of 4IR initiatives, from an automated check-out procedure, to advancing search parameters, and to wellness programs for students, based on their opted-in data, etc. Our quest, herein, is for a way forward to see "impediments" as "opportunities" and this is our change management course. The university's library has, in particular, become a hub of 4.0 activities – this allows for cross-disciplinary dialogue – it is ultimately about ethically-aligned AI. The aspect of both emotional and ethical intelligence emerges through cross-disciplinary dialogue as the approach brings about continuous reflection.

A growing pain of utilizing AI technology is the resource intensity of producing useful results. Complex models reliant

on massive amounts of data require processing infrastructure that, in most cases, is simply not available to academics and graduate students. In order for academia to continue its contribution, collaborative industry and cloud computing initiatives are necessary [8]. This has been a growing problem for researchers and the institutions within which they function, and enumerating the enablers and barriers for the adoption of cloud computing services in academia has become a key challenge. Software as a service comes into play, which has gained traction as a model for many business applications, and entails a thin client (through e.g. a web browser) that provides access to centrally hosted software. This is fairly similar to the operation of a traditional gateway. A similar interface to computational infrastructure for university students and researchers could be explored, with the potential of commercial monetization of such resources providing a sustainable financial model in order to provide such services to students.

V. We Can, But Should We?

Section III alluded to an important aspect of the increasingly remote learning constraints that higher education is being forced to operate in, given the global pandemic. The foundations of universities are laid upon critical thinking. The example of MOOCs discussed earlier is representative of the bigger question surrounding the integration of University 4.0 and the extent to which that augments the campus experience and by extension, the role and identity of the university as an institution. The university serves a crucial role in society and is indeed much more than an institution through which a qualification can be earned, also providing tremendously important social experiences that are often immensely impactful on the remainder of the students' life.

One of the basic human psychological needs – the need for contact with other human beings – has been accentuated during the COVID-19 pandemic perhaps more than ever. The complexities of interaction between human beings do not permit remote contact to satisfy our basic need for face-to-face interaction [9]. This is self-evident for our case of higher education, including psychosocial implications. Regardless of the ever-increasing costs, students flock to attain the campus experience, of which the degree awarded at the end of their tenure is but a small part.

VI. Conclusion

South Africa's higher education systems have developed inclusiveness, excellence and is undergoing transformation. Going forward, we're interested in better and appropriate utilization of student data – to see how we can provide student support in various ways. For example, utilizing Blackboard Predict, we can attain early-warnings of a student who's struggling and determine the appropriate support intervention. We've embedded chatbots, for example into our law programs, where the chatbot smartens based on questions asked and responses seen favorable by a qualified professional (in the approach, the online agent self-learns and improves). For cross-disciplinary education – we are looking to infuse a "1+1" model for innovation – an approach that helps our students to think inside the box, outside the box, without the box and towards the "internet of things!" We are therefore seeing technologies as a way for furthering our approach for education that transforms society, simultaneously developing inclusiveness and deepening excellence. We need to however ensure that we accelerate an augmented approach for cybersecurity – we see that with growth in internet of things, and other areas of connectivity, the security loopholes will grow perhaps even faster and much awareness is necessary regarding this. An equally driven effort towards data security, contending the dark web, and that user privacy is maintained. Alongside the technological challenges, societal impact must also be incorporated in the transition to a more connected higher education experience.

In homeostasis, we expect higher education will be more hybrid than ever before. A greater online approach, enhancing student-centered customization, access and excellence, augmented with in person, transdisciplinary interactions. But ultimately, it must be borne in mind that the purpose of education is beyond merely acquiring skills, and develops preparedness for life-long learning – this is how graduates adapt to the ever-changing world of work.

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